Exotic versus indigenous trees: The current and future composition of forests in Amani Nature Reserve

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Abstract

This study assessed the current status of indigenous and exotic species and aimed to predict the future composition of the forest in Amani Nature Reserve. Seedling communities were mostly dominated by *M. eminii* while *A. stuhlmannii* dominated sapling communities suggesting that *M. eminii* is recruiting poorly probably due to its failure to survive under shade. It was concluded that shade-tolerant species will have a much higher chance of dominating the future composition of the forest.

INTRODUCTION

Amani Nature Reserve is located on one of the East Usambaras, part of the broader Eastern Arc Mountains that stretch from the Taita hills in Kenya to the southern highlands of Tanzania (Lovett, 1992). Gazetted in 1997, Amani Nature Reserve is among the more recent protected areas in Tanzania and constitutes six forest reserves, namely Amani-Zigi, Amani East, Amani-West, Kwasambia, Kwamkoro and Mnyuzi Scarp. About 1,068 ha of Amani Nature Reserve forest was donated by the Usambara Tea Company while the rest is public land (TBA, 2010).

Amani Nature Reserve boasts great biodiversity and endemism of both flora and fauna and the Eastern Arc mountains are among the global biodiversity hotspots. For instance, Amani Nature Reserve harbours the important tree *Allanblackia stuhlmannii* and for centuries local inhabitants have used its seeds to yield oil, food and for soap production (Monela *et al.,* 2001; Osemeobo, 2005). The microclimate in Amani Nature Reserve has attracted people for various purposes, most notably agriculture due to its relatively high rainfall and fertile soils. As such tea plantations are also situated within Amani Nature Reserve to take advantage of the suitable weather.

Before its gazettment Amani Nature Reserve underwent unsanctioned resource use including massive logging for 15 consecutive years. As part of its rehabilitation, several exotic species including *Maesopsis eminii* were introduced to hasten the process of restoration by providing shade to some endemic tree species such *Cephalosphaera usambarensis* (TBA, 2010). Due to their weedy characteristics, largely the annual production of enormous seed crops and their ability to colonise gaps, *M. eminii* in particular managed to spread quickly outside their introduction points and invade other areas to the extent of threatening the survival and vigour of the forest. A number of studies have been conducted to see how much invasive species have spread and their impacts on biodiversity in Amani Nature Reserve though none has yet assessed the future structure and composition of the forest. This study assessed the current status of indigenous and exotic species and aimed to predict the future composition of the forest in Amani Nature Reserve.

OBJECTIVE

The main objective of this study was to assess the current composition of the forest and predict the future composition of both indigenous and exotic tree species though characterization of seedling communities.

METHODOLOGY

Study area

This study was conducted in Amani Nature Reserve which is found in the East Usambara Mountains, Tanzania. The East Usambara Mountains cover an area of 1,300 km^2 and lie between 4°48', 5°13' S and 38°32', 38°48' S (Hamilton & Bensted-Smith, 1989). This study was carried out across several forest blocks of Amani Nature Reserve namely Western, Derema and Monga.

Methods

Random sampling was conducted within three selected forest blocks. In total, 30 transects were laid in 10 blocks of which six were from the Western block, two from Derema block and two from Monga block. In each block three (50 x 10 m) transects were laid at 100 m intervals 100 m away from the edge of the forest towards the interior. Within transects, all adult trees (above 20 cm dbh) of selected species were identified and enumerated. Furthermore, all seedlings (< 1 cm dbh) and saplings (1-10 cm dbh) underneath the trees (2.5 m radius) were identified and counted. Seedling height was measured while dbh readings for all saplings were recorded.

Data analyses

Non-metric Multidimensional Scaling (NMDS) was used to describe the seedling communities (analysis conducted in CAP, Pisces Software) and derived axis components were further analysed by general linear models. A general linear model test was used to compare the relationship between seedling communities and other variables such as tree species, location of forest blocks, distance from the edge of the forest and transect numbers. (Minitab statistical software version 13.32)

RESULTS

Large tree communities

A total of 30 transects were surveyed across three forest blocks of Amani West, Derema and Monga. Generally, large tree species occur at a density of 168 stems/ha of the surveyed area. Results from the surveyed forest blocks suggest there are mostly seedlings of *M. eminii* followed by *N. buchananii*, *P. excelsa*, *C. usambarensis* and *A. stuhlmannii*, (Figure 1).

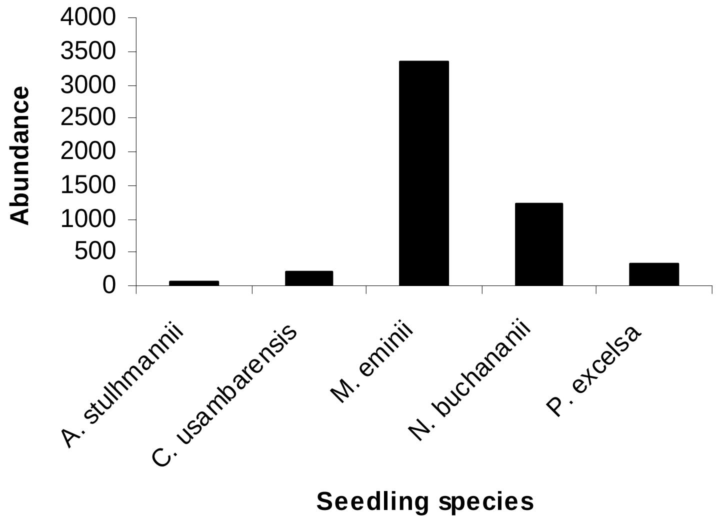


Figure 1. Histogram of seedling abundance among species.

Conversely, sapling communities were dominated by *A. stuhlmannii,* followed by *C. usambarensis*, *P. excelsa*, *N.* bu*chananii* and *M. eminii* (Figure 2). This indicates poor recruitment of *M. eminii* to the sapling stage, but strong recruitment of *A. stuhlmannii*.

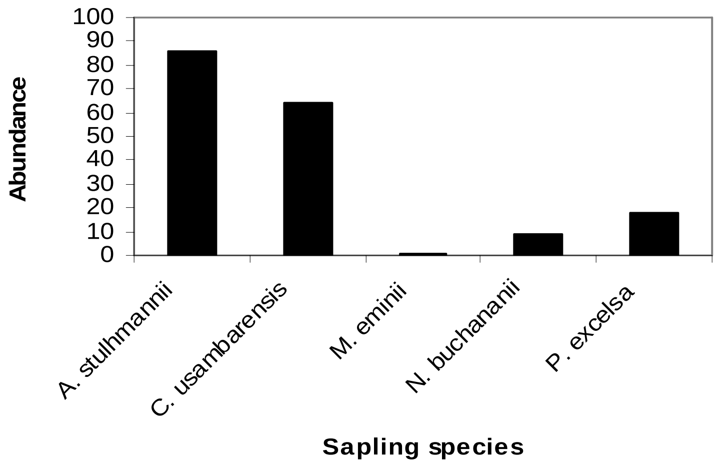
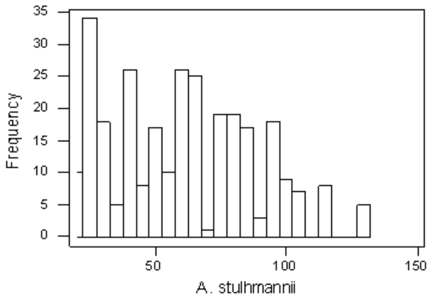


Figure 2. Histogram of sapling abundance among species.

Trees of *A. stuhlmannii* and *P. excelsa* were observed to have an even size distribution (Figure 3).



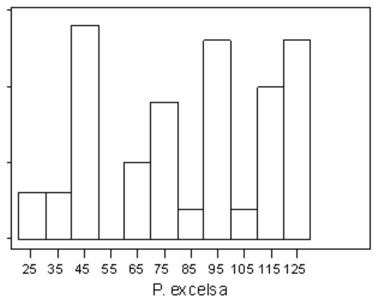
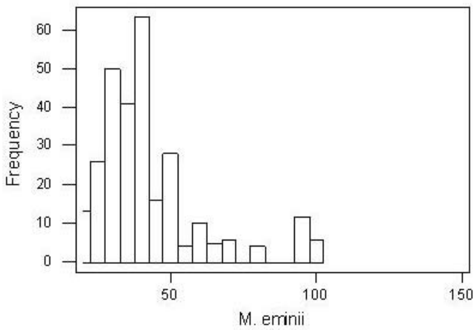


Figure 3. Frequency distribution of *A. stuhlmannii* and *P .excelsa* trees.

Maesopsis eminii and *C. usambarensis* tree species showed a different tendency with medium-sized trees dominating adult tree communities (Figure 4).



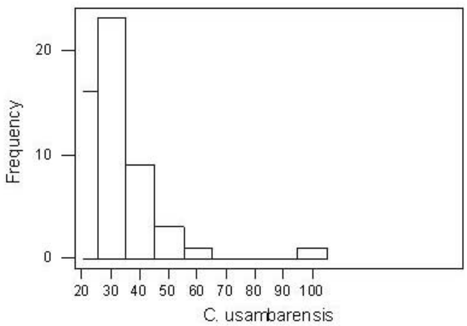
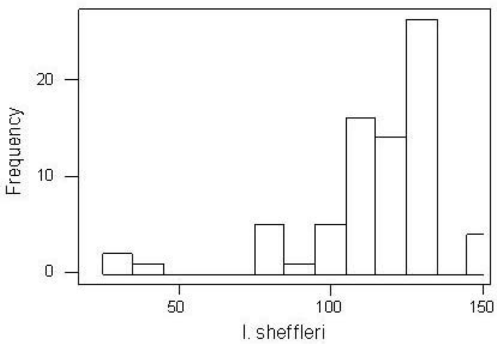


Figure 4. Frequency distribution of *M. eminii* and *C. usambarensis* trees.

Large tree communities of *I. sheffleri* were observed to have fewer medium trees and a lot of adult trees while *N. buchananii* had a lot of medium-sized trees and few adult trees (Figure 5).



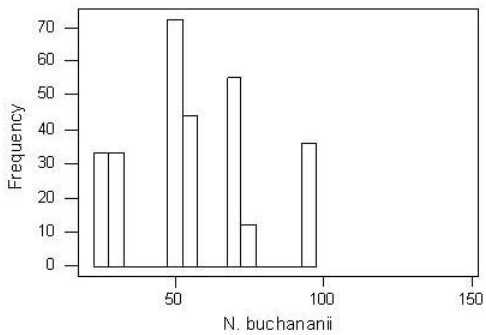


Figure 5. Frequency distribution of *I. sheffleri* and *N. buchananii* trees.

Seedling communities

Seedlings communities underneath large trees were analysed using NMDS to separate seedling communities along two derived axes (Figure 6).

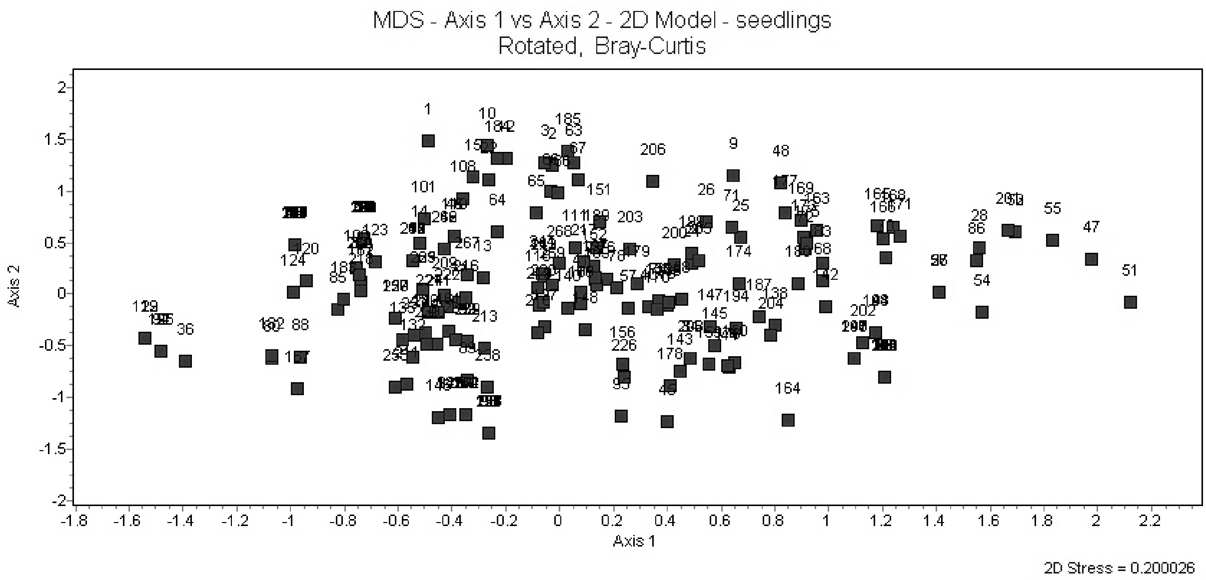


Figure 6. NMDS analysis showing clear separation of seedling communities along two derived axes.

Analysis of the first derived axis showed significant variation among locations ($F_{2,\ 214}$ = 7.32, P = 0.001) and transects ($F_{2,\ 214}$ = 3.70, P = 0.026). Tukey's independent test showed variation between Amani West Monga forests blocks (Figure 7). There was no significant variation among tree species ($F_{9,\ 214}$ = 1.10, P = 0.367) or with distance from the edge of the forest ($F_{1,\ 214}$ = 0.36, P = 0.547).

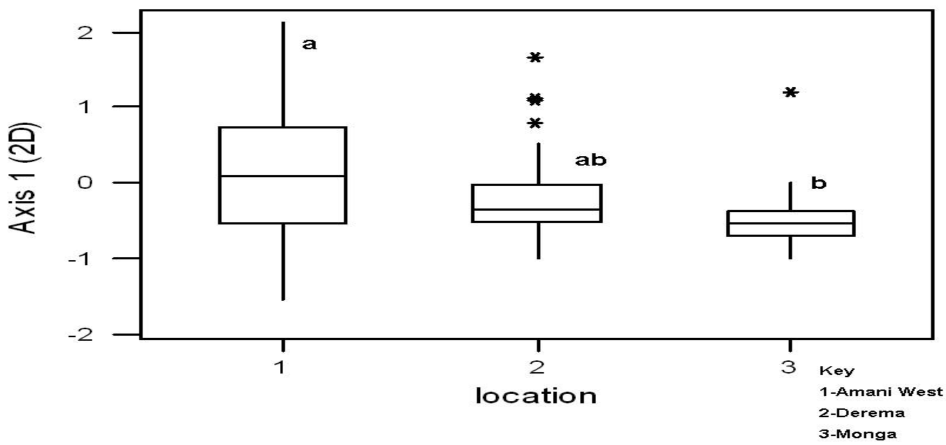


Figure 7. Variation in seedling communities across different locations. Means ± se. Bars with different letters are significantly different (Tukey's HSD, alpha = 0.05).

Analysis of the second derived axis showed significant variation among tree species ($F_{9, 214}$ = 3.18, P = 0.001) (Figure 8), distance ($F_{1, 214}$ = 6.20, P = 0.014) (Figure 9), and location ($F_{2, 214}$ = 3.24, P = 0.041).

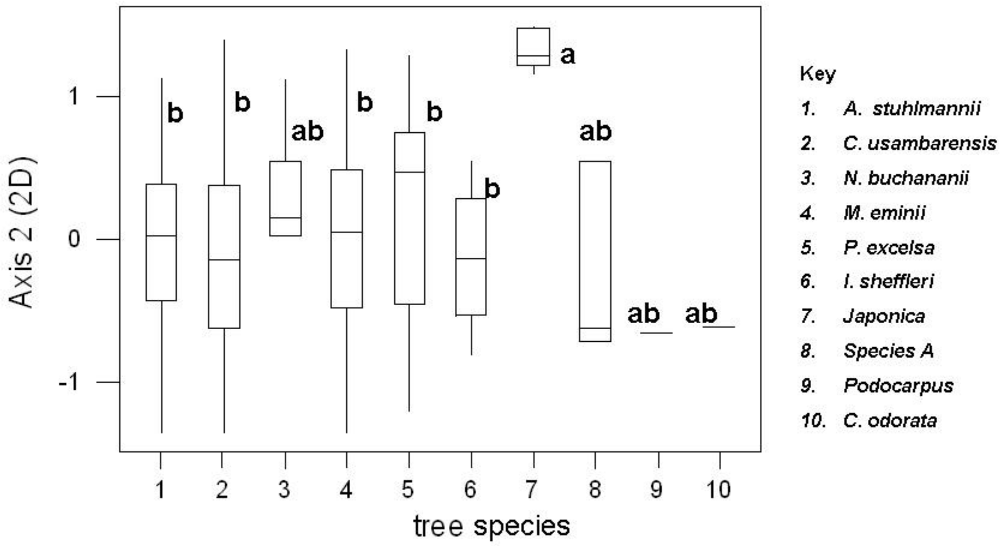


Figure 8. Variation in seedling communities among tree species. Means ± se Bars with different letters are significantly different (Tukey's HSD, α = 0.05).

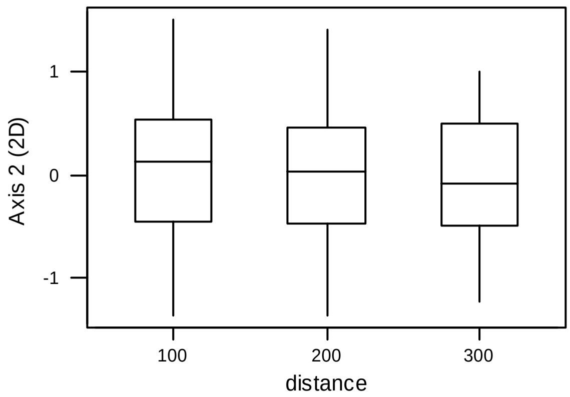


Figure 9. Variation in seedling communities across different distance. Means ± se.

Results from individual seedling species (Table 1) show *A. stuhlmannii* seedlings vary in abundance among locations (more species were found in Amani West forest block) but there was no significant variation among adult tree species and distance from the edge of the forest.

Seedling communities for *C. usambarensis* showed significant variation among locations and distance (seedlings were more near the edge of the forest and decreasing towards the interior) from the edge of the forest. No significant variation was observed among tree species.

For *M. eminii* seedling communities, no significant variation was observed among locations, tree species and distance. *Newtonia buchananii* show significant variation among locations and tree species however there was no significant variation among distance from the edge of the forest. *Parinari excelsa* seedling communities showed significant variation among locations but there was no significant variation among tree species and distance from forest edge.

Table 1. Variation in seedling communities among different parameters

	A. stuhlmannii	*C. usambarensis*	*M. eminii*	*N. buchananii*	*P. excelsa*
Location	***	*	ns	*	*
Tree species	ns	ns	ns	***	ns
Distance	ns	***	ns	ns	ns
<u>Key</u> P>0.05 ns P<0.05 * P<0.01 ** P<0.001 ***					

DISCUSSION

Tree communities

Large tree communities of *A. stuhlmannii, C. usambarensis, N. buchananii* and *P. excelsa s*how an inverse J shape which indicates that these tree species have more juvenile trees as compared to adult trees (Figure 1& 2). This could be attributed to the fact that these particular tree species are shade-tolerant and can successfully survive high canopy cover with a limited amount of sunlight. As such, we think these trees have a much higher chance of dominating the future generation composition of the forest.

Other large tree species however have a trend which doesn't follow the normal pattern. *Maesopsis eminii* and *I. sheffleri* had a pattern which suggests may be there are fewer or no juvenile trees with many adult tree (Figures 4 & 5). This might be associated with poor recruitment by these species. In particular *M. eminii* is known to perform poorly under shade since it is a light-demander and grows very well in gaps where sunlight can easily penetrate to the ground.

Seedling communities

The model indicates that seedling communities differ in different locations (i.e. Western, Derema and Monga blocks) (Figure 7). Maybe the presence of different human activities could have some impacts on seedling communities. For instance the Western block of Amani Nature Reserve is surrounded by human settlement, shambas and most importantly the presence of Amani Botanic Garden in the periphery. These might influence seed dispersal, especially of exotic species which were introduced in several trial plots. In a similar scenario, Derema block also has human settlements as well as tea plantations. Land clearance for human settlement and farms normally create gaps which change tree compositions hence seedling communities as well. Contrary to Western and Derema, Monga forest block is a primary forest with little human interference and therefore few non-native tree species were found.

Unsurprisingly, seedling communities differ with distance from the edge of the forest towards the interior. As it was mentioned earlier, the ongoing human activities facilitate seed dispersal and the most like point of introduction is on the edge of the forest. Adding to the fact that at the edge of the forest there is much light and space which is created by human activities, seedlings tend to grow more and faster and the rate diminishes as you proceed towards the interior of the forest.

It is worth noting that, seedling communities in all locations did not indicate any relationship with large tree species in the canopy. Even when individual seedling communities were tested against large tree the responses were not significant. This might be associated with several factors but most probably the species of canopy tree is of limited importance in determining the recruitment of species beneath.

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